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GRAND MISSION VERSUS SMALL OPS TEAM CAN WE HAVE BOTH?

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ABSTRACT.- Space Missions are growing more ambitious, but resources are getting smaller. Is this a contradiction in terms, or is it a healthy challenge?

This paper offers the author's point of view as a member of a small Mission Operations Team that carries out an ambitious international mission (Ulysses ESA/NASA).

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INTRODUCTION

So...Can we have both?

Right or wrong, the answer to this is being written by all of us, the people who work in the Space Business. We make the choices and in so doing we define the future.

In the other hand nobody is absolutely free to shape history. Forces like the economy and the development of the technology *invite* us to take certain decisions.

Actually it seems that we are at the same time invited and decided to have bigger but cheaper missions. Maybe the relevant question is no longer whether it is possible or not but:

How are we going to do it?

The following discussion will help us to answer this question. After all, we are the problem solvers in this game and this is a good place to talk about our solutions.

TODAY'S FACTS

Space and the economy

Space is nowadays a precious economic resource and the number of services it offers is increasing every day.

The missions that provide a commercial service grow as big as the market requires them to grow. They tend to use well-proven technologies and to build spacecraft in a production-line fashion.

The non-commercial missions tend to grow smaller under the economic pressure. Like the dinosaurs they disappear or evolve into birds under the pressure of the environment.

In the other hand we need the non-commercial missions to expand our knowledge. This tends to increase their mission cost, because it constitutes a bigger challenge than following the paved way.

Fast technology development

The new technologies may multiply the possibilities or lower the cost, but their novelty involves a greater risk.

Technology acts frequently as a hidden agenda. The conservative side of the project will defend the Mission Objectives above all, while some groups will be very motivated to develop a particular technology. This is not necessarily bad, because the new technologies are a desirable product of the space activities.

Man versus Machine

Here is another controversial issue, in which there is a case for either side.

Machines are more accurate, but they lack many human virtues. Robots are cheaper to fly, because they do not need life support. To

reduce the man power on the ground, we use artificial intelligence that is not cheap, but its development is an attractive hidden agenda.

In any case, we humans have an exploring heart and we cannot help to be part of the space exploration endeavor. This emotional imperative seems to be a key ingredient of progress because it generates motivation, which is essential for the future of any business.

HOW DID WE GET HERE

It is well known that the Space research started during the cold war. Now we are in the post cold war and the base of our economy is changing. Unfortunately fear to one another is a big incentive for the research and the economic growth; it is not surprising that we have lost some steam in this change process.

In the mean time we have become accustomed to re-direct part of our energy towards space exploration and to the business opportunities thereof. We should hope that this challenge would help us to substitute war as the prime incentive to advance science and technology.

SUMMARY OF OUR SITUATION

Like in the legend of Ulysses, we are caught between Scylla and Charibdes (a narrow strait between two opposite rocks). Nevertheless, there is nothing like a good challenge to make people think harder.

Before we talk about the way out, it would be a good idea to discuss what are our objectives.

OBJECTIVES

Do more and to do it for less

This is in simple terms the key question. It is possible but we must be aware that it requires significant cultural changes; we cannot expect to do it for less just following the traditional rules. We also must accept that changing the rules involves some risk.

Maintain people's motivation

People want to know, why should we pursue space research?

We need to conduct our missions in a way that satisfies people's needs and appeals to people's participation. We will not go very far if we do not take into account the fact that customers and professionals are just people.

Insure operational flexibility

Space Operations is about: having options, knowing them well, and applying them as required. Usually a mission does not turn out as expected and we need to combine our options in a way that is different from the nominal plan.

Satisfy the customer

Who is the customer? The obvious customer is the user of the service that the mission provides. There are also indirect customers like the development of technology, the government, the tax payer, etc.

Be efficient

Avoid over-killing solutions in any part of the process. The key factor here is: how justifiable are our requirements?

We can probably agree that we want to accomplish most of the above requirements, but the question is still: how? Let us review some of our available alternatives.

ALTERNATIVES

Use small teams

There is a *critical mass* of people, beyond which a chain reaction occurs, that further increases their number and makes the organization less efficient. This critical number seems to be around 20 or 30 people.

If you have a larger team you start to need more bureaucracy and more people to pull them together.

- *Hire the right people.* If we have a small team we do not have lots of redundancy. Therefore it is important to get the right combination of talent, personalities and experience.
- *Provide the right motivation.* The engine of human nature works mainly with two kinds of fuel: positive motivation and negative motivation. The best one is by far the positive motivation that we create by means of the following elements:
 - *An attractive vision and clear goals.* Examples: "We want to get *there* and achieve *that* great objective"; "We are here to deliver this product and to make this customer happy."
 - *A shared destiny.* "We are in the same ship, and we want to cooperate in order to safely arrive to our destination, so that we can share the success."
 - *Recognition and empowerment.* Let us show appreciation for the contribution of each member of the team. Let us allow each individual to feel his/her sharing of

the driver seat. We are more likely to volunteer our energy if we realize that it leads others towards the common goal.

- *The right pay-checks.* We can do wonders with a small team of great highly motivated people, but their motivation would not last long if we do not pay them well.
- *Co-locate people.* If everybody is in the same area, people will naturally talk to one another. Ideas will flow easier and they will need fewer memos and meetings. This has a magic effect on cost.
- *Lower cultural barriers.* People in a productive team may and should come from different backgrounds. They should be different in order to complement one another, but they should respect and welcome the differences. They should also be prepared for not being able to understand one another some times.

Use new technologies

A small team can implement a grand mission but they will require more powerful tools to be able to handle it.

The funding scheme could be a problem in the case of the operations technology. Normally the funding for operations is distributed over a number of years, and it is difficult to invest up front in powerful operations technology.

Keep the system simple

Do not incur in unnecessary complications. Both the spacecraft and the ground system should be as simple as possible. A mission becomes cheaper and also safer in this way. The following are different aspects that we can try in this area:

- *Small spacecraft.* A good way to keep it simple is to make it smaller. Sometimes a single small spacecraft cannot accomplish a grand mission, but for what we are saving we can afford to buy more than one.

The smaller the spacecraft the shorter the time and the cost to completion.

- *More missions.* If they start to be cheaper we could have more; this means: "to distribute the eggs in different baskets." Also the learning curve of the new technologies gets faster if we launch more missions.
- *Provide feed-back to the requirements.* It is healthy to periodically check-out the relevance of the requirements that have a significant cost impact. Sometimes the customer does not really want what he asked for, particularly if he knows that it is going to cost him much more money or risk.

RISKS AND PROBLEMS

Now let us look for the obstacles that we have in our way:

Mission Failures.

Recently there have been some examples, but they seem to be distributed among missions with different sizes. We could expect higher risk from an ultra-low-cost mission, but the truth is that the big ones also fail, and when they do fail, they have a much bigger repercussion.

Size versus influence.

The smaller the project the smaller the weight it has within its organization, and the

reverse is also true. A project with a large budget represents a higher bet for the organization and will have a stronger voice when it comes to compete for resources.

This is an interesting management challenge. We have to protect the small-budget missions from being suffocated by the big ones, but we have to keep the big ones in good shape, because they damage badly the organization if they fail.

Lack of redundancy.

When reducing the cost, the redundancy is one of the things that tend to be suppressed. This applies both to the team and to the spacecraft and ground system design. This maybe OK if we lower the cost so much that we can do a second mission, but we must accept the fact that the mission becomes more likely to fail.

Nevertheless, the no-redundancy game could be very good for very small projects that we can afford to repeat several times by even trying different technologies.

Excess of automatism .

Auto-pilot is a great thing, but we normally do not fly on a plane without helm controls plus a pilot who knows how to use them. If the automatic function fails it is good to have a reliable "go to manual" key and a few well-trained people around.

Loss of interest

If we depend too much on the machines we have three negative effects:

1. People tend to forget how to operate in the manual mode that may be needed in an emergency. This requires continuous attention to training.
2. People lose interest for a system that does not give any opportunity to enjoy the

driver seat. That makes them to lose motivation to learn more about it

3. The public interest seems to react negatively to the machine winning the contest. Without this interest the space business would continuously decay.

If we are not careful, the human versus machine issue could severely damage the human motivation to pursue space research. Therefore, we should address and try to suggest a win-win solution to this problem among the recommendations below.

RECOMMENDATIONS

Small team with powerful technology

This is at least a possible solution to the problem: Grand Mission versus Small Operations.

In the term small team we should read all the good things that we have considered in the section ALTERNATIVES and not only the size of the team.

Special attention should be given to the funding peak required to buy up front the powerful hardware and software that will make it possible for a small team to handle the mission.

Harmonize human and machine

One would say that the artificial intelligence systems are no longer a simple tool but a knowledgeable colleague. If flying in auto-pilot is not very appealing to human nature, having to recognize that the machine is becoming an expert is quite hard on our pride.

The win-win solution to this conflict that we are going to suggest is to facilitate a good relationship between both sides.

We humans could try to admit that the expert systems are becoming intelligent members of the team that have much to offer. Nevertheless, if a system has to be accepted as another member of the team it has to behave like one. It has to show the equivalent of *good manners*, and emulate the behavior of a reasonable human negotiator. It would not be a bad idea to program also some algorithms to respond to the human colleagues by showing recognition and nicely empowering the human initiatives.

For the programmers of the *expert systems* it is an interesting challenge to design such a *colleague-friendly* interface. Besides it will probably pay off to the developers as well, because a product as this is likely to capture the interest of many users.

Some people may think that this project is not worth the effort, but they should consider that Ignoring the human factor has always been very detrimental to any business.

CONCLUSION

Can we have, a grand mission but small operations team? Yes, we can.

How? We should try to combine a small affective team with *user-friendly* advanced technology.

It is indeed a challenge, but it is a very healthy and constructive one. The space business has probably grown a bit inefficient as part of its natural evolution.

We could compare our business to a mature apple-tree that has grown a bit too much. It is now the right time to prune it and to prepare it for a fruitful growth.

CLARIFICATION

I have tried to share on this paper my personal ideas and opinions as an individual member of the Ulysses Operations Team. Nevertheless, my ideas do not represent the official opinion of the Ulysses Project.